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AN APPROACH TO HOT LABORATORY DESIGN

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AN APPROACH TO HOT LABORATORY DESIGN

Gibson Morris[1]

We have learned from the preceeding talks some of the problems associated with massive shielding requirements and remote operation of conventional equipment. Prior to the time these cells and remote equipment are designed, the Laboratory scale of these same operations have been carried out. Thus, to complete the picture of the facilities needed in the over-all scheme of research and development we actually start in the private or individual laboratory. Since the preceding discussions have dealt with "hot" operations or activities that require full protection for the personnel involved, we will confine this paper to the "hot" laboratory.

It is a wonderful age in which we now live and all of our modern devices are usually born as a result of research conducted in someone's laboratory.

Most of us as a result of our own experience or through the medium of advertising have seen how important the kitchen in the modern home has become. And the equipment for today's kitchens--today's housewife plans her kitchen space and her equipment for maximum efficiencies, safety and ease of operation. She needs equipment which will heat and bake, cool and freeze, agitators and mixers. She needs scales and measuring devices, hot water and cleaning facilities. She requires an exhaust fan or hood to keep the area free of fumes. She demands that her equipment be located in such a manner that her physical movements be held to a minimum. She insists that adequate storage space be provided. And finally she requires ample work areas with surfaces which can be quickly and easily cleaned over and over again. Yes, the kitchen in the modern American home is becoming the central point of our better living. And, in the rapidly moving search for knowledge in the fields of chemistry and physics, so has the laboratory become one of the most vital tools in the hands of our scientists. It is interesting to note the parallel requirements between our modern kitchen and our research laboratory. Basic items of equipment show a remarkable resemblance. In this discussion of a "hot" laboratory we start with the conventional and we build into the installation the necessary safety features which are a must. In addition, we strive for continued economy through utilization of maximum efficiency from services and equipment, and simplicity in materials.

Today, there are two major schools of thought with regard to the operating technics in the average hot lab. This discussion is not intended to debate these issues but merely to call attention to the fact that in the opinion of the author, each has its own merits and its own limitations. On the one hand we could design and install a hot laboratory with an absolute minimum of cost and rely heavily on the research personnel, through their operating procedures to provide the necessary safety and required efficiency. On the other hand we can incorporate in the laboratory itself the safety features and the tools which are needed to provide the flexibility and maximum usefulness as required. Just as our grandmothers managed to feed her family with limited equipment,

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in the one case so can a laboratory be deprived of the modern equipment. And in the other case, as today's kitchen provides the facilities for a wider selection to satisfy our requirements, so the modernly equipped laboratory places at the disposal of the research groups the facilities so necessary for the successful completion of their undertakings.

Let us look more specifically now at the "hot" laboratory of today, and first define what we call "hot". This term has been used more and more of late as we have embarked on the road of nuclear energy development. The term "hot" simply means that radioactive materials are present and therefore the necessary precautions such as biological shielding, specific air collection and filtering, and waste disposal requirements have been introduced into the otherwise normal laboratory operations. And, the engineering approach — since we have introduced the handling of radioactive materials into these laboratories we must emphasize the need for careful examination of the design problems to ensure that the really necessary precautions are taken and that extravagant overdesign does not occur.

During the last few years many papers and articles have been presented on the over-all subject of laboratory building designs. On how architectural effects are involved -- discussions on materials of construction -- different methods of handling and confining radioactive particles -- any number of these well defined and interesting documents are available to each of you, from the Atomic Energy Commission, the National Academy of Sciences, the National Bureau of Standards, the National Laboratories, and many other organizations such as your own A.S.C.E. This being the case, let us just briefly then consider the basic requirements involved in the design of a "hot" laboratory.

Space and Size

As far as possible, all areas should be kept free and open, through the use of movable partitions so that complete flexibility is possible with regard to initial layout, future revisions, and later readjustments. This would also call for a uniform floor load design, floor covering, head room, and ceiling treatment.

A modular principle should be adopted in order that services may be placed to permit a maximum flexibility and a uniform approach to the installation of equipment. This will permit not only a lower initial cost but likewise will reduce later maintenance expenses.

It has been found that bays about 24 feet square lend themselves more readily to the subdivisions which will be most useful. This module is subdivided with facility into lesser modules so that workable units are then available in any combination desired. Two 24-foot wide laboratory strips on each side of a central supply of services may in turn be flanked by two other 24-foot wide strips. From these two latter strips an 8-foot width of corridor may be subtracted leaving a 16-foot width along the exterior walls of the structure, wherein can be located offices, stock room, or any other space directly related to the operation of the laboratory.

Materials of Construction

The type of space enclosure may be varied. Long range planning of the programs to be carried out in the laboratory may indicate that movable metal partitions are the best choice. This selection should be compared with, say, a dry wall type of masonry. Realistic cost data, both from the standpoint of initial investment and for future flexibility in rearrangement, should be

considered. In any case a suitable surface finish which will not harbor radioactive particles and is readily cleanable of surface contamination is essential. This can be achieved by sealing the wall joints with a chemically inert material or tape and applying over the entire surface a corrosion resistant paint.

Floor coverings should be durable and readily replaceable. We must assume that sometime during the use of a laboratory in which radioactive materials are handled that an occasional "spill" will occur.

Many types of floor surfaces have been tried at the various Atomic Energy installations. Smooth finished concrete with a tough plastic surface treatment -- or covered with large sections of vinyl resin sheet material with the joints sealed -- various mixtures of concrete topping materials -- these treatments have proved to be rather expensive and in general not very satisfactory. Our most recent experience and one which is very promising is the use of ordinary asphalt tile squares. This material is not too expensive by comparison; it wears well under traffic, and above all it is easy to replace in the event of a spill. Only those sections which have become contaminated need be replaced. And for a small additional cost we can place a layer of felt or some other material between the concrete and tile which will further assure the protection of the concrete. Actually, our experience shows that asphalt tile squares tend to "flow" under continuous use and in so doing seal the joints even more tightly. Remember that we are talking about a laboratory where our level of activity is low. For areas in which the higher levels of activity are dealt with we must utilize more resistant materials such as stainless steel.

Services

As mentioned before, the over-all design of the laboratory, especially in a building with large groups of individual lab space, the distribution of utilities becomes a matter of prime importance. Initial installation cost and ease of maintenance are basic considerations. Provision for flexibility within the laboratory, that is, the ability to rearrange equipment, should also influence the layout of utilities.

We have found that easy access to drain lines and hood ducts for the purpose of replacement or decontamination is necessary. For these reasons we believe that a distribution system designed on the universal space concept is preferred. In this system, utilities, drains, and ducts are led up through service channels spaced on a module along the corridor wall. Each service would be valved and teed at each outlet and distribution into the laboratory would be made along the wall in service racks. The service channels and the service racks would all be enclosed thus eliminating any exposed piping which would present a difficult problem in maintaining cleanliness.

Ventilation

Because of the potential hazard from radioactive dusts and gases efficient ventilation is required. The direction of air flow should always be from uncontaminated areas such as corridor and offices to potentially contaminated areas

Not too long ago before hood designs were changed and before we had developed some of the very sensitive equipment which we now find necessary in a laboratory, it was the general feeling, because we could not recirculate air through laboratories that air conditioning and humidity control were too expensive. Today we have designed new laboratory hoods which operate

efficiently with approximately 1/2 the air flow previously thought necessary. In addition, newly developed equipment used in the laboratory for greater accuracy and broader research is very sensitive to temperature and humidity changes. Therefore, we must attempt to provide conditioned air on an economical basis.

The most recent development in this field has been the redesign of laboratory hoods. This new design permits, (1) a safe 50 FPM face velocity, (2) constant rate of room exhaust and uniform face velocities for any hood door position by use of bypass dampers. Other changes in the hood design have improved its efficiencies, just as the modern kitchen has reached its present degree of perfection in our homes. Here then is one way in which we may engineer some of the problems that will confront us during the design of a new laboratory. Simply by redesigning one of the major pieces of equipment, the hood in the laboratory, we have reduced the volume of air to be handled and as a direct result we reduced our refrigeration load by some 65%. This is enough to now make it economical to proceed with temperature and humidity control. And most important of all, we have provided the research worker a safer and more efficient tool.

Waste Disposal

To complete the design of a new radiochemical laboratory we must include a waste collection and monitoring system. If we are building a small single unit then waste collection becomes an integral part of that laboratory. If we are installing a new building, housing many laboratory units, then a common collection system can be utilized. In either case, this is a must in the installation and should be engineered taking into consideration the type of waste, and the most economical method for its disposal. This is a subject in itself and your own files will give you the necessary information.

The foregoing summary suggests the basic considerations which must be "engineered" in order to produce a "hot" laboratory that is safe, efficient and economical. How do we engineer it? Simply this ---

We must establish a closer and more understanding relationship between the scientist and the engineers; neither is self-sufficient. Engineering is admittedly more complicated today but it is still based upon a sound and thorough understanding of well known engineering principles. In the field of Nuclear Energy Development the engineer, along with his usual requisites and abilities, should consider a new philosophy in approaching these problems. This new philosophy is born out of knowledge that remote control, shielding, zero maintenance, surgical cleanliness and radiation damage are primary factors which must precede or at least run concurrent with the usual engineering consideration.

The critical factors which must be established and reconciled for each laboratory facility are, (1) contamination, (2) the upper limit for total activity and anticipated material losses based on the specific technics being used, (3) the proportion of space needed for each activity level, and (4) the cost in time, money and interference to the program to provide adequate protection in the event of a mishap. All work must be planned so that both the probability risk and the consequence are acceptable.

Because of the wide range between the levels of radiation from the microcurie to the multicurie scale involved in current research activities, the problem of designing working spaces in which this research may be carried out efficiently and safely necessarily has no single solution. Therefore, in this particular field, the design engineer should become a part of the research

and development team early in the conception stage of any new laboratory facility planning.

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